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Retrospective evaluation of chest computed tomography findings of the patients diagnosed with COVID-19

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Abstract
Aim: In our study, we aimed to analyze laboratory findings, presentation symptoms and thoracic CT findings of patients who were admitted to the emergency department of our hospital with symptoms of COVID-19, had positive results of RT-PCR tests, and were referred to our radiology clinic.
Material and Methods: Patients' demographic data such as age and gender, symptoms on admission, PCR and CT outcomes were recorded and analyzed. In CT examinations, laterality, the presence of consolidation and/or ground-glass opacities (GGO), and central and/or peripheral distribution were analyzed.
Results: A total of 74 patients aged 20-87 years who were found to be COVID-19 positive using RT-PCR test were included in our study. When examining the initial admission symptoms, patients were found to have complaints such as fever, cough, shortness of breath, weakness and sore throat. When the thorax CT findings of the patients included in the study were examined, bilateral and unilateral involvement, anterior and posterior localization, presence of apical involvement, peripheral and central distribution, multilobar and unilobar involvement, GGO, consolidation, vascular thickening, crazy paving, fibroatelectasis, subpleural band, air bronchogram, pleural effusion, pleural thickening, cavitation and mediastinal LAP findings were detected.
Discussion: It is still premature to use CT alone instead of RT-PCR. However, the findings accumulated in the literature show that a trend has begun to develop in this regard. A definitive diagnosis must be confirmed by CT scan in patients who show typical symptoms of COVID-19, even though the PCR test is negative, especially in adults.

Keywords
COVID-19; Radiology; Computed Tomography; RT-PCR

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Introduction

The coronavirus-2019 disease (COVID-19), caused by coronavirus 2 (SARS-CoV-2), which emerged in Wuhan, China's Hubei province in December 2019 and progressed with severe acute respiratory syndrome, is still spreading rapidly all over the world [1]. COVID-19 pneumonia causes severe respiratory disease, and its main clinical symptoms are fever, cough, shortness of breath, myalgia and weakness [2, 3]. Symptoms such as diarrhea, hemoptysis and headache are also among the symptoms of COVID-19 disease [4]. Early diagnosis is very important, since the source of infection can be not only symptomatic patients, but also patients in the incubation period.

The mortality rate from COVID-19 pneumonia has been reported to be high in some populations with comorbidities such as diabetes and hypertension, especially in the elderly [5, 6]. The epidemic was declared a pandemic by the World Health Organization (WHO) in March 2020, and according to WHO data, around 1 million deaths were recorded with 32.7 million cases all over the world on 27/09/2020 (available at: https://covid19.who.int/).

The socio-economic impacts of the highly contagious COVID-19 disease also continue to increase. Although studies to find vaccines and drugs for COVID-19 pneumonia continue, no specific vaccine or drug treatment has yet been found. The gold standard method used to detect COVID-19 pneumonia is the reverse transcription polymerase chain reaction (RT-PCR) test. Although the RT-PCR test is thought to have high specificity, the sensitivity of this method is reported as low as 60-70% [6]. Therefore, chest computed tomography (CT) is frequently used together with RT-PCR. Thorax CT is known to be more sensitive compared to RT-PCR, but thorax CT may also be normal in the early period of the disease and in asymptomatic cases. In imaging studies, it is difficult to distinguish COVID-19 from influenza A virus, influenza B virus, cytomegalovirus, adenovirus, respiratory syncytial virus, SARS-CoV, MERS coronavirus and other viral pneumonias as well as pneumonia caused by bacterial pneumonia [7].

In our study, we aimed to analyze the laboratory findings, presentation symptoms and thoracic CT findings of patients who were admitted to the emergency department of our hospital with symptoms of COVID-19, who had positive results of RT-PCR tests, and were referred to our radiology clinic.

Material and Methods

A total of 74 patients who were admitted to the emergency service of our hospital with COVID-19 symptoms between 15/03/2020 and 15/06/2020 tested positive for COVID-19 using the RT-PCR test, and who were referred to our clinic for radiological imaging were included in our study. Our study has a retrospective design and was conducted in a single center. Necessary permissions and ethics committee approval were obtained before starting the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Demographic data of the patients such as age and gender, presentation symptoms (fever, cough, dyspnea, myalgia, etc.), contact history, laboratory findings (leukocyte, CRP), ground glass opacities (GGO), consolidations, paving (crazy-paving) finding, typical CT findings such as vascular enlargement, air bronchogram, bronchial wall thickening and bronchiectasis, reticulation, subpleural lines, linear opacities, fibrosis, Halo sign, Inverse halo sign (Atoll's sign), air bubble and pleural thickening, and the presence of atypical CT findings such as pleural effusion, pericardial effusion, lymphadenopathy, the appearance of budded branches were investigated and recorded.

CT Acquisition Technique

As part of our hospital's COVID-19 guidelines, after the RT-PCR swabs, all patients underwent chest CT to determine the presence or absence of viral pneumonia. All chest CT examinations were performed with patients in the supine position during end inspiration without contrast medium injection. Chest CT was performed on a 128-slice CT scanner (GE Revolution EVO 64 Slice CT Scanner; GE Medical Systems, Milwaukee, Wis) dedicated for COVID-19 patients only. The following technical parameters were used: tube voltage, 120 kV; tube current modulation, 100–250 mAs; spiral pitch factor, 0.98; and collimation width, 0.625. Reconstructions were performed using the convolution kernel BONEPLUS (GE Medical Systems) at a slice thickness of 1.25 mm. The decontamination of the room consisted of surface disinfection with 62%–71% ethanol or 0.1% sodium hypochlorite. After each chest CT examination, passive air exchange was performed for 40–60 minutes.

Disposable bed covers were used during each examination, and the CT device and room was completely disinfected after each patient's examination.

Statistical analysis

SPSS 23.0 (SPSS Inc. USA) was used for the statistical analysis of the data obtained in the study. Continuous variables are expressed as mean ± standard deviation, minimum and maximum values, and categorical variables as numbers and percentages. The p-values <0.05 were considered statistically significant.

Results

A total of 74 patients aged 20-87 years who tested positive for COVID-19 sing the RT-PCR test were included in our study. Forty of the patients were male (54.1%) and 34 were female (45.9%). In terms of gender, there was no statistically significant difference between males and females (p> 0.05). The mean age of all patients was 51.74 ± 18.23 years. The mean age of men was 52.8 ± 18.23 years, and the mean age of women was 50.64 ± 18.58 years. In terms of mean age, no statistically significant difference was found between male and female patients in terms of age (p> 0.05).

When the initial admission symptoms of the patients were examined, it was found that they presented with complaints such as fever, cough, shortness of breath, weakness and sore throat. The mean fever of the patients at the time of admission was 37.0 ± 0.7 (min-max: 36-39) degrees. When each of the admission symptoms was examined separately, only fever was detected in 11 patients, only cough in 19 patients, and malaise in 7 patients. The remaining 37 patients were determined to present with more than one symptom. When the laboratory data of the patients included in the study were examined, the mean leukocyte value was 7.27 ± 3.07 (min-max: 2.85-17.77 K /

uL). The leukocyte value was found to be 7.18 ± 3.07 (min-max: 2.86-16.08 K / uL) in male patients and 7.30 ± 3.04 (min-max: 2.85-17.77 K / uL) in female patients. The leukocyte value in 50 cases (67.6%) was within the normal reference range. It was found that 15 patients (20.3%) had low leukocyte levels and 9 (12.2%) had high leukocyte values.

When the CRP values of the patients were examined, while the mean CRP levels were within the normal range in 32 patients (43.2%), it was found to be increased in 42 patients (56.8%).

When the thorax CT findings of the patients included in the study were examined, bilateral and unilateral involvements, anterior and posterior localization, presence of apical involvement, peripheral and central distribution, multilobar and unilobar involvements, GGO, consolidation, vascular thickening, crazy paving, fibroatelectasis, subpleural band, air bronchogram, pleural effusion, pleural thickening, cavitation and mediastinal LAP findings were detected. Thoracic CT findings of the patients are presented in Table 1.

No Reverse Halo and appearance of budded branches findings were found in any of the 74 patients included in the study. Sample CT images of the patients are shown in Figures 1-3.

Table 1. Thoracic CT findings of COVID-19 patients

CT Findings	n	%
Involvement	52	70.3
Bilateral	45	86.5
Unilateral	7	13.5
Localization		
Posterior	17	32.7
Anterior/Posterior	35	67.3
Apical Involvement	20	27.1
Distribution		
Peripheral	40	76.9
Peripheral + Central	12	23.1
Multi/Uni Lobular		
Multilobular	50	96.1
Unilobular	2	3.9
GGO	51	69.0
Consolidation	13	17.6
GGO / Consolidation Size		
0-3 cm	29	45.3
0-3 cm, > 3 cm	22	34.4
Infiltration Distance to Pleura		
0-1 cm	26	35.2
0-1 cm, >1 cm	25	33.8
	Present (n)	**Present (n)**
Vascular Thickening	6	8.1
Crazy Paving	12	16.2
Fibroatelectasis	23	31.1
Subpleural Band	23	31.1
Air Bronchogram	2	2.7
Pleural Effusion	1	1.3
Pleural Thickening	2	2.7
Cavitation	1	1.3
Traction Bronchiectasis	3	4.1
Mediastinal LAP	5	6.7

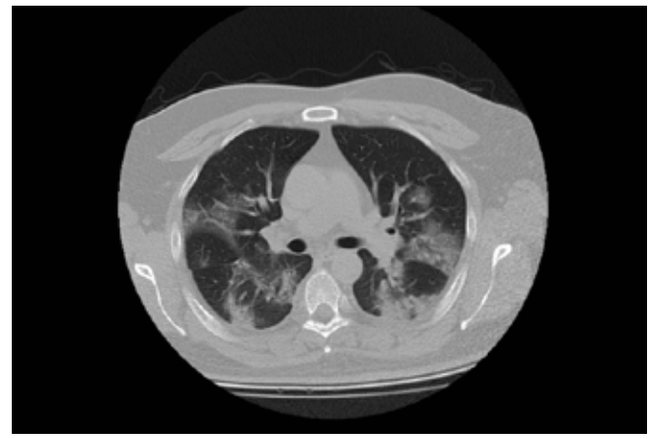

Figure 1. A 66-year-old male patient presented with shortness of breath and cough symptoms. When examining a CT image, there are GGO areas, consolidation, crazy paving and pleural thickening.

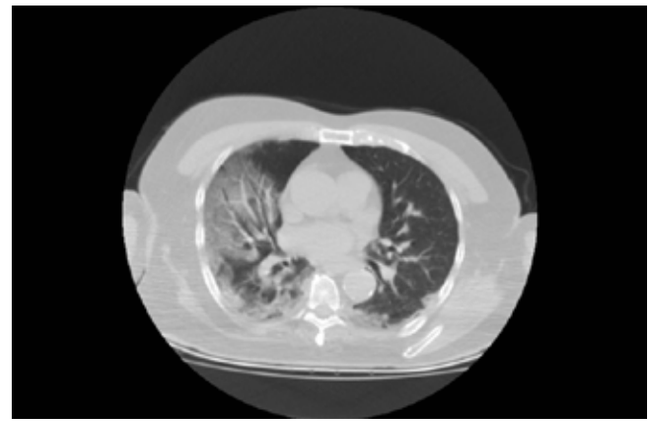

Figure 2. A 58-year-old male patient. Presentation symptoms were fever, cough and shortness of breath. CT findings: GGO areas, consolidation, vascular thickening, left pleural thickening and subpleural band are observed.

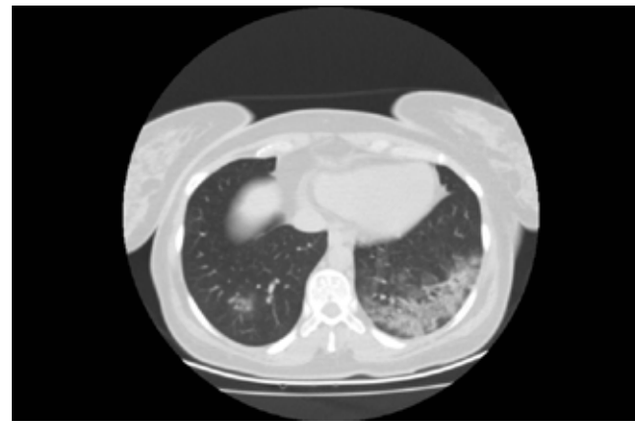

Figure 3. A 44-year-old female patient. Admission symptoms were fever and cough. The observed CT findings were GGO and consolidation.

Discussion

Diagnosis of COVID-19 pneumonia is based on clinical symptoms, RT-PCR testing, CT scanning, and serology blood tests. The most common laboratory abnormalities in positive RT-PCR patients are leukopenia, thrombocytopenia, elevated CRP and inflammatory markers, increased cardiac biomarkers,

decreased albumin, and liver kidney and liver function [8, 9]. In our study, we examined the admission symptoms, laboratory results and thorax CT findings of patients in whom COVID-19 diagnosis was confirmed with RT-PCR test.

In our study, the average age of the patients was 52. In the study by Yurdaisik et al. with 50 patients, the average age was 54 [10]. Similarly, Wang et al. reported that the average age was 56 in their study in which they analyzed COVID-19 patients [11]. When we examine the initial presentation symptoms of 74 patients included in the study, we have found that they most frequently presented with fever, cough, shortness of breath and malaise. In other studies, previously published in the literature, it was reported that the most common presentation symptoms were fever, cough, shortness of breath, and malaise [10, 12].

When we examine the laboratory findings of the patients, while the mean CRP level was within the normal range in 32 patients (43.2%), it was found to be increased in 42 patients (56.8%). Looking at previous studies examining COVID-19 patients, Li et al. reported that CRP was within the normal reference range in 56 patients (43%), and increased CRP in 75 patients (57%) [10]. In a study conducted by Chen et al., 63 of 73 COVID-19 patients (86%) had increased CRP levels and in the studies conducted by Guan et al., it was observed that CRP increased in 481 (60.7%) of 793 COVID-19 patients [13].

Some of the previously reported studies in the literature reported a decrease in leukocyte ratio [4, 13, 14], and some reported that the leukocyte ratio increased in COVID-19 patients [15, 16]. When we examine laboratory tests of the patients, we found that the leukocyte value of 50 COVID-19 patients (67.6%) was in the normal reference range, the leukocyte value of 15 patients (20.5%) decreased, and the leukocyte value increased in 9 patients (11.2%). In the study of Chen et al. in which 99 COVID-19 patients were analyzed in China, it was reported that 24 patients (24%) had an increase in leukocyte levels and in 9 patients (9%), there was a decrease in leukocyte levels [16].

When we examine the CT findings of our study, we found that a total of 52 patients (70.3%) had lung involvement, 45 of them had bilateral and 7 had unilateral involvement. Bilateral involvement was found in 91% of the patients in the study conducted by Caruso et al. in Italy, in 86% of the patients in the study by Song et al. [17] and in 75% of the patients in the study by Bai et al. [18]. As in our study, it is seen that bilateral involvement is much higher than unilateral involvement in other studies reported in the literature. Seventeen of these involvements are located posteriorly, and 35 are anterior/posterior located. Again, apical involvement was observed in 20 patients.

Among 52 patients with involvement (70.3%), 40 (78%) had peripheral distribution and 12 (22%) had peripheral + central distribution. Similar to our study, in the study conducted by Zhou et al., the peripheral distribution rate of COVID-19 patients was reported as 77.4% [15]. In a study by Xu et al., they reported that the peripheral distribution was observed in 78% of the patients [19], and in another study conducted by Harrison et al., it was reported that 80.4% of the patients had peripheral distribution [20].

In patients with involvement, 50 of the involvements (96.1%) were found to be multilobar involvement and 2 patients (3.9%) had unilobar involvement. In the study by Sana et al. investigating 919 COVID-19 patients, the rate of multilobar involvement was reported as 78.8% [21].

When the literature is reviewed, studies have shown that the most prominent CT finding of COVID-19 patients is GGO. In our study, 51 of the 74 patients (69.0%) had GGO and 13 (17.6%) had consolidation. In the study conducted by Song et al., GGO rate was reported as 76.5% [18]. Similarly, in the study conducted by Shi et al., the GGO rate was 65.4% and the consolidation rate was 17.3% [22]. In a meta-analysis evaluating a total of 13 studies, the incidence of GGO was reported to be 69% [23].

Other CT findings in patients with involvement are as follows: fibroatelectasis in 23 patients (31.1%), subpleural band in 23 patients (31.1%), crazy paving in 12 patients (16.2%), vascular thickening in 6 patients (8.1%), mediastinal LAP in 5 patients (6.7%), traction bronchiectasis in 3 patients (4.1%), air bronchogram in 2 patients (2.7%), pleural thickening in 2 patients (2.7%), cavitation in 1 patient (1.3%), and pleural effusion in 1 patient (1.3%).

Limitations of the Study

First of all, our study was conducted in a single center. On the other hand, the number of participants in our study was relatively high compared to similar studies. Other hemogram parameters, such as neutrophil, monocyte, platelet, and mean platelet volume, which have been widely investigated in studies, could also be studied. However, this would have made it difficult to focus on the CT findings, which was the main purpose of the study. We believe that the findings of our study will contribute to the existing evidence. However, our findings should be supported by large-series multi-center studies.

Conclusion

The pandemic caused by the COVID-19 virus continues to affect many people around the world and causes the death of many people. Vaccine/drug development efforts continue in many countries, including our country. However, unfortunately, even if an effective vaccine is found, it will best be applied to large populations in the second half of 2021. Considering all these, the importance of early diagnosis and treatment in COVID-19 comes to the fore. The low sensitivity and high prevalence of false negatives of the gold standard RT-PCR test necessarily require confirmation of the diagnosis by other methods. Laboratory parameters have a certain diagnostic value. However, laboratory findings vary widely between studies. In this case, chest CT is of great importance as a diagnostic confirmatory. Especially as the pandemic continues, the importance of breast CT will gradually increase. It is still premature to use CT alone instead of RT-PCR. However, the findings accumulated in the literature show that a trend has begun to develop in this regard. A definitive diagnosis must be confirmed by CT scan in patients who show typical symptoms of COVID-19, even though the PCR test is negative, especially in adults.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with

the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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